

What is claimed is:

1. An improved echo control system of the type including:
 - an echo-containing near signal input;
 - an echo canceller, coupled to a far signal reference, producing an echo estimate signal output representative of the echo contained in the near signal;
 - a signal coupling node, coupled to the near signal input and the echo estimate signal output, producing an echo-canceled signal output having an echo residue;
 - an echo shaping filter, coupled to the echo-canceled signal output, reducing the echo residue and providing an echo-suppressed signal output, the echo shaping filter having a spectral response determined by filter coefficients; and
 - a background filter, coupled to:
 - (a) an error signal representative of the difference between:
 - (i) the echo canceled signal, and
 - (ii) a signal representative of background filter spectral response, and
 - (b) an adaptive control module producing a reference signal output that is a weighted sum of:
 - (i) the echo-containing signal, and
 - (ii) the echo canceled signal,
- the background filter updating the filter coefficients of the echo shaping filter responsive to a normalized least mean square (NLMS) algorithm;
- wherein the improvement comprises:
- determining, in the adaptive control module, a reference signal weight for the weighted sum, the weight being proportional to the far signal reference;

and an estimate of the norm of an echo canceller error vector, and inversely proportional to an estimate of a residue of the echo canceller; and

using a non-linear normalized convergence term in the NLMS algorithm.

2. An improved echo control system according to claim 1, wherein the echo canceller is a finite impulse response (FIR) filter.
3. An improved echo control system according to claim 1, wherein the echo shaping filter is a finite impulse response (FIR) filter.
4. An improved echo control system according to claim 1, wherein the background filter is a finite impulse response (FIR) filter.

5. An improved echo control system according to claim 1, wherein the echo canceller error vector is determined as:

$$\Delta w(k) = w_{ep} - w(k)$$

where $\Delta w(k)$ represents the echo canceller error vector, w_{ep} represents a physical echo path identified by the echo canceller, and $w(k)$ the echo canceller response.

6. An improved echo control system according to claim 1, wherein the reference signal weight is determined as:

$$\alpha(k) = \frac{\beta \|\Delta w(k)\| \bar{x}_s(k)}{\bar{e}_s(k)}$$

where $\alpha(k)$ represents the reference signal weight, β represents a constant normalizing term, $\|\Delta w(k)\|$ represents an estimate of the norm of the echo canceller error vector,

$\bar{x}_s(k)$ represents a short-term average magnitude of the far signal reference, and $\bar{e}_s(k)$ represents a short-term average magnitude of the echo canceller residue.

7. An improved echo control system according to claim 6, wherein the echo canceller error vector is determined as:

$$\frac{N + N_T}{N_T} \sum_{i=1}^{N_T} |w_i(k)|$$

8. An improved echo control system according to claim 1, wherein the NLMS update algorithm is:

$$\mathbf{h}(k+1) = \mathbf{h}(k) + \frac{\mu}{\zeta + \mathbf{z}(k)^T \mathbf{z}(k)} \mathbf{z}(k) e_h(k)$$

where $\mathbf{h}(k)$ represents the echo shaping filter having an order L_H , $\mathbf{z}(k)$ represents a vector representing the L_H most recent values of the reference signal output, $e_h(k)$ represents the error signal, ζ represents a non-negative constant, and $\frac{\mu}{\zeta + \mathbf{z}(k)^T \mathbf{z}(k)}$ represents a normalized convergence coefficient.

9. An improved method of echo control of the type including:
 providing an echo-containing near signal input;
 producing, with an echo canceller coupled to a far signal reference, an echo estimate signal output representative of the echo contained in the near signal;
 producing, with a signal coupling node coupled to the near signal input and the echo estimate signal output, an echo-canceled signal output having an echo residue;

reducing, with an echo shaping filter coupled to the echo-canceled signal output, the echo residue and providing an echo-suppressed signal output, the echo shaping filter having a spectral response determined by filter coefficients; and

providing a background filter, coupled to:

- (a) an error signal representative of the difference between:
 - (i) the echo canceled signal, and
 - (ii) a signal representative of back ground filter spectral response, and
- (b) an adaptive control module producing a reference signal output that is a weighted sum of:

- (i) the echo-containing signal, and
- (ii) the echo canceled signal,

the background filter updating the filter coefficients of the echo shaping filter responsive to a normalized least mean square (NLMS) algorithm;

wherein the improvement comprises:

determining, in the adaptive control module, a reference signal weight for the weighted sum, the weight being proportional to the far signal reference; and an estimate of the norm of an echo canceller error vector, and inversely proportional to an estimate of a residue of the echo canceller; and

using a non-linear normalized convergence term in the NLMS algorithm.

10. An improved echo control method according to claim 1, wherein the echo canceller is a finite impulse response (FIR) filter.

11. An improved echo control method according to claim 1, wherein the echo shaping filter is a finite impulse response (FIR) filter.
12. An improved echo control method according to claim 1, wherein the background filter is a finite impulse response (FIR) filter.
13. An improved echo control method according to claim 1, wherein the echo canceller error vector is determined as:

$$\Delta w(k) = w_{ep} - w(k)$$

where $\Delta w(k)$ represents the echo canceller error vector, w_{ep} represents a physical echo path identified by the echo canceller, and $w(k)$ the echo canceller response.

14. An improved echo control method according to claim 1, wherein the reference signal weight is determined as:

$$\alpha(k) = \frac{\beta \|\Delta w(k)\| \bar{x}_s(k)}{\bar{e}_s(k)}$$

where $\alpha(k)$ represents the reference signal weight, β represents a constant normalizing term, $\|\Delta w(k)\|$ represents an estimate of the norm of the echo canceller error vector, $\bar{x}_s(k)$ represents a short-term average magnitude of the far signal reference, and $\bar{e}_s(k)$ represents a short-term average magnitude of the echo canceller residue.

15. An improved echo control method according to claim 6, wherein the echo canceller error vector is determined as:

$$\frac{N + N_T}{N_T} \sum_{i=1}^{N_T} |w_i(k)|$$

0.7977	0.7976	0.7975	0.7974	0.7973	0.7972	0.7971	0.7970
11	12	13	14	15	16	17	18
0.7969	0.7968	0.7967	0.7966	0.7965	0.7964	0.7963	0.7962
19	20	21	22	23	24	25	26
0.7961	0.7960	0.7959	0.7958	0.7957	0.7956	0.7955	0.7954
27	28	29	30	31	32	33	34
0.7953	0.7952	0.7951	0.7950	0.7949	0.7948	0.7947	0.7946
35	36	37	38	39	40	41	42
0.7945	0.7944	0.7943	0.7942	0.7941	0.7940	0.7939	0.7938
43	44	45	46	47	48	49	50
0.7937	0.7936	0.7935	0.7934	0.7933	0.7932	0.7931	0.7930
51	52	53	54	55	56	57	58
0.7929	0.7928	0.7927	0.7926	0.7925	0.7924	0.7923	0.7922
59	60	61	62	63	64	65	66
0.7921	0.7920	0.7919	0.7918	0.7917	0.7916	0.7915	0.7914
67	68	69	70	71	72	73	74
0.7913	0.7912	0.7911	0.7910	0.7909	0.7908	0.7907	0.7906
75	76	77	78	79	80	81	82
0.7905	0.7904	0.7903	0.7902	0.7901	0.7900	0.7899	0.7898
83	84	85	86	87	88	89	90
0.7897	0.7896	0.7895	0.7894	0.7893	0.7892	0.7891	0.7890
91	92	93	94	95	96	97	98
0.7889	0.7888	0.7887	0.7886	0.7885	0.7884	0.7883	0.7882
99							
0.7881							

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